Environment Canada Environnement Canada

10209261 VOL ISS 58 850400
EXC # 001
TD 171.5.C3 R46
REPORT EE

OOFF

REPORT ON THE BEAUFORT SEA SMALL SCALE OIL SPILL DISPERSANT TRIAL

EE-58

REPORT ON THE BEAUFORT SEA SMALL SCALE OIL SPILL DISPERSANT TRIAL

by

A. Dickinson
D.F. Dickens Associates Ltd.
Vancouver, B.C.
D. Mackay
University of Toronto
Toronto, Ontario
D. McWatt
Beaufort Sea Environmental Support Services
Aklavik, N.W.T.

This report has not undergone detailed technical review by the Environmental Protection Service and the content does not necessarily reflect the views and policies of Environment Canada. Mention of trade names or commercial products does not constitute endorsement for use.

This unedited version is undergoing a limited distribution to transfer the information to people working in related studies. This distribution is not intended to signify publication and, if the report is referenced, the author should cite it as an unpublished report of the Branch indicated below.

Any comments concerning its content should be directed to:

Environmental Emergencies Technology Division
Technical Services Branch
Environmental Protection Programs Directorate
Environmental Protection Service
Environment Canada
Ottawa, Ontario
K1A 1C8

EE-58

April, 1985

CONTENTS

	Page
ABSTRACT	1
1.0 INTRODUCTION	2
2.0 TEST PROGRAM DESCRIPTION	3
3.0 RESULTS AND FIELD OBSERVATIONS	4
4.0 RECOMMENDATIONS AND CONCLUSIONS	23
ACKNOWLEDGEMENTS	25
LIST OF PARTICIPANTS	26
APPENDICES	

LIST OF TABLES

Table		Page
1	Environmental Conditions	7
2	Sorbent Weighing Results	8
3	Water Sample Analyses	9

LIST OF FIGURES

Figure		Page
1.	Location Map.	3
2.	Boom configuration.	4
3.	"Solo" 15 litre backpack spray unit.	5
4a.	Start of 20 litre oil slick.	10
4b.	20 litre oil slick after 30 seconds.	11
5.	Test section of sorbent pads.	11
6.	Placing sorbent strips.	12
7.	Sketch showing progression of Spill #2.	13
8.	Sketch showing progression of Spill #3.	15
9.	Sketch showing progression of Spill #4.	17
10.	Sketch showing progression of Spill #5.	18
11.	Sketch showing progression of Spills #6 and 7.	20
12.	Sketch showing progression of Spill #8.	22

ABSTRACT

On September 4, 1984, a small scale oil spill dispersant demonstration was conducted 2.5 nautical miles northeast of Shingle Point in Mackenzie Bay. The main reasons for the demonstration were to provide northern people with actual experience in applying dispersants on oil, and to evaluate the viability of using small scale spills to determine dispersant effectiveness. This report deals solely with the scientific aspects of the project. A discussion of results and future experimental design considerations is included.

To meet the scientific objectives, a minimum of 16 spills with two oils and three dispersants were scheduled in a detailed work plan. At least two spills were needed to determine how the oils were likely to spread and drift. Another six spills involved mixing oil with a dispersant prior to release to ensure that the dispersant was effective and to compare products. Finally, a series of eight spills were to be sprayed with dispersant in a practical demonstration.

The original work plan required a minimum of two full days of testing to spill about 360 litres of crude oil and diesel fuel, with the dispersants Corexit 9550 and 9527, and BP MA700. Unfortunately, the necessary support vessel was available for only one day on site, and half of the experiment was left incomplete. There was insufficient time available to properly assess the dispersant spray application, or to arrange for Mark Bobra (University of Toronto) to observe the dispersant application. In spite of these disappointments, the test did meet part of the initial objectives. A series of premixed oil/dispersant tests were successfully completed, and indicated significant differences between dispersant products. The concept of using a boomed channel in an open sea environment was shown to have great potential for future small scale dispersant tests. Local people were able to actively participate in both the application of dispersants and documentation of dispersant effectiveness.

1.0 INTRODUCTION

There is continuing interest in the application of dispersants to oil spilled in arctic waters. The actual effectiveness of dispersants employed in cold waters is still the subject of considerable controversy, which neither laboratory tests nor large scale offshore experiments have been able to resolve to the mutual satisfaction of government and industry.

How useful will dispersants be in dealing with an arctic spill incident, and what are the environmental criteria controlling their practical effectiveness? The answers to these questions require evidence collected under representative conditions, and local familiarity with dispersants and their application. The primary objective of the small scale demonstration described here was to introduce local clean-up personnel to the complexities of dispersant use in the arctic.

Secondary objectives were to develop a better appreciation for relative dispersant effectiveness under cold water conditions, and to evaluate the concept of using small scale controlled field spills for future dispersant testing.

This demonstration was not intended to be a rigourous scientific test. Basic environmental data was collected, and the behaviour and effectiveness of the different dispersants documented in as much detail as possible.

2.0 TEST PROGRAM DESCRIPTION

The test site was located in Mackenzie Bay, N.W.T. about 2.5 nautical miles northeast of Shingle Point (Figure 1).

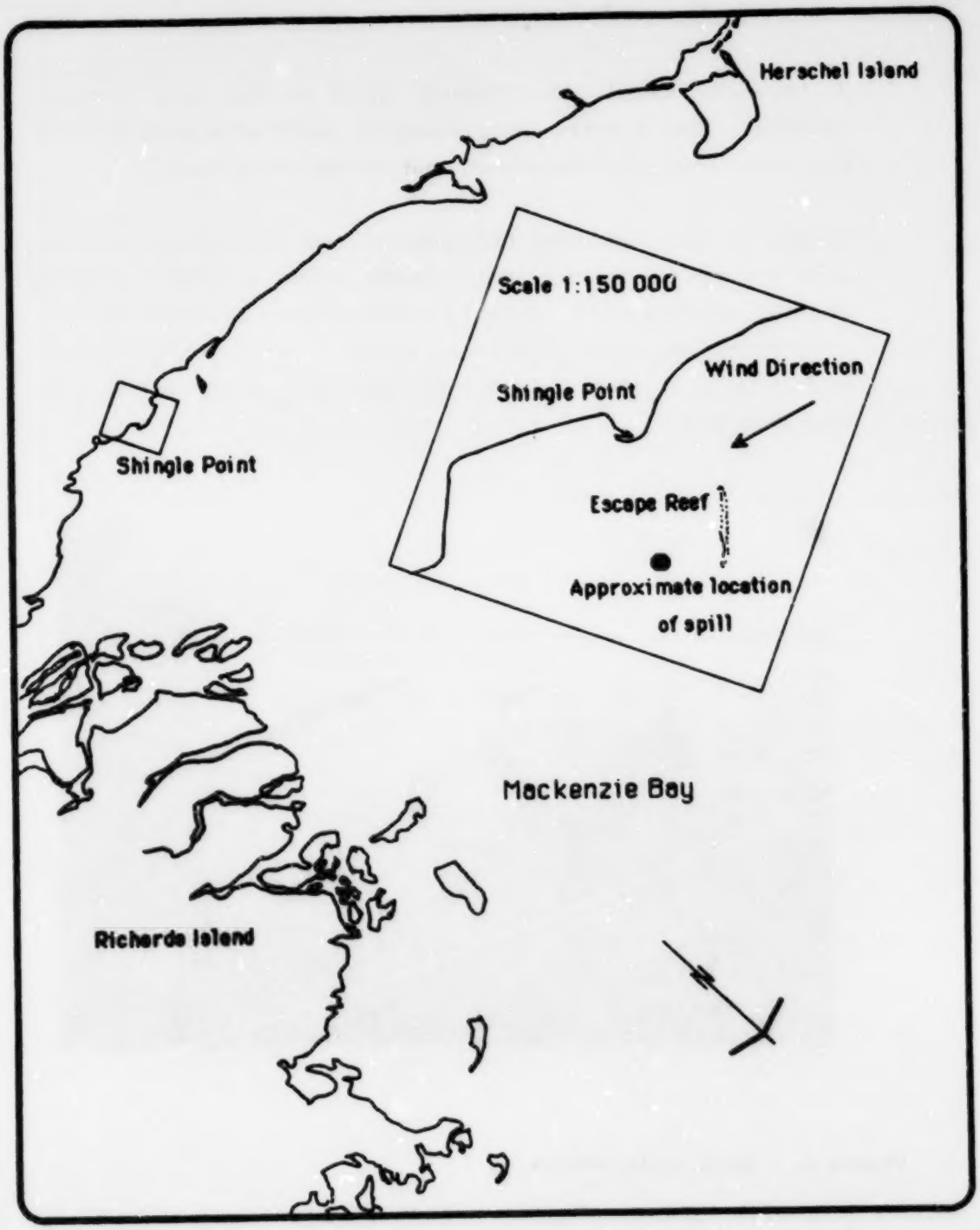


Figure 1. Location Map.

A 12 metre vessel, the "Sequel" acted as the main working platform. Two 4 metre Lund aluminum boats were used to tend the boom, spray the dispersant, and handle the sorbent.

Design of the dispersant test program was centred around the basic concept of spilling small volumes within a boomed channel, oriented with the wind. Figure 2 shows the two 23 metre containment booms deployed on site, with two 3 metre sorbent booms lashed to a 6 metre pole to maintain boom separation at the downwind end.

Figure 2. Boom configuration.

The sorbent booms were installed to prevent any oil from escaping into the surrounding water. Strips of sorbent rolls or pads placed about 1 metre upwind of the sorbent boom were used for primary clean-up, and collected for weighing after each test.

Based on Don MacKay's suggestions, a detailed test plan was plotted using a flowchart to show the combinations of various oil and dispersant types and different oil/dispersant ratios from 1:5 to 1:20. This test plan involved a systematic progression from some initial spills to arrive at the most suitable oil volume, to premixed oil and dispersant and finally to the spray application of dispersant. Appendix C contains a copy of the test plan prepared in advance of going into the field. Two 15 litre capacity herbicide sprayers were used as spray applicators (Figure 3).

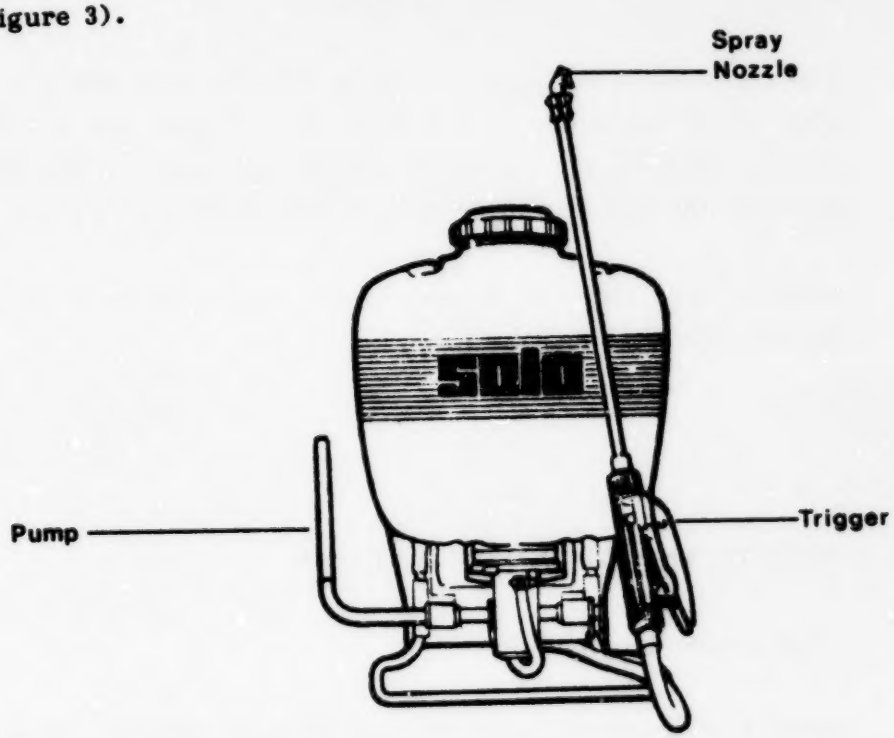


Figure 3. "Solo" 15 litre backpack spray unit.

The brass spray nozzle was fully adjustable from a mist to jet when spraying water. The maximum operating pressure was 90 psi.

Environmental parameters monitored during the demonstration included:

. wind speed and direction (hand anemometer)

. water/air temperature (thermistor)

. current speed/direction (direct read-out Savonius rotor type meter on loan from Institute of Ocean Sciences)

. wave height/period (estimated and timed)

. boom direction (degrees magnetic)

Water samples were collected from a 1 metre depth using a submersible pump suspended from a buoy located near the centre of the channel (Figure 2). A water sample was taken at the start and finish of the day and after each surface slick reached the buoy.

Samples were shipped to Seakem Oceanography in Sydney, B.C. for analysis (see Section 3.0).

3.0 RESULTS AND FIELD OBSERVATIONS

. Environmental Conditions

Table 1 summarizes the environmental data collected between 1103 and 2215 hours on September 4, 1984. Conditions were generally favourable with water and air temperature about equal at 5°C. There was a moderate sea state in 7 to 12 knots of wind. The boom usually lay within 40° of the wind direction.

Table 1: Environmental Conditions

Time	Air			Water			Height (ft)	Wave Period (sec)	Boom Direction (°M)
	Temp (°C)	Speed (kt)	Direction (°M)	Temp (°C)	Speed (kt)	Direction (°M)			
1103	4	10	250	5.32	<0.5	160			90/270
1200	2	11	220	5.30	<0.5	160	2	2.3	70/250
1330	8	10 to 11.5	310	5.30	<0.5	270	1.5 to 2	2.6	160/340
1545	6	10	310	5.35	<0.5	270			160/340
1627	5	8	315	5.35	<0.5	320			140/320
1701	5.5	8	300	5.35	<0.5	250	1.5	2.5	110/290
1750	5.5	7	320	5.35	<0.5	310			130/310
1845	5	2.5 (Beaufort)	350	5.35	<0.5	290	1.5 to 2	2.5	125/305
2002	5	9	310	5.35	<0.5	160	2.5	3.2	110/290
2051	5	11	340	5.32	<0.5	220	3	3.2	115/295
2140	4	8	360	5.30	<0.5	190	3	2.3	100/280
2215	6	9	320	5.27	<0.5	160			140/320

Notes:

1. Environmental measurements were taken by Beaufort Environmental Support Services employees and Anthony Dickinson.
2. Wave heights were estimated using a stick with 1 foot markings.
3. Water depth 2.5 m.
4. Period was measured by counting time for ten waves. There was some problem with this as wind waves with a much shorter period (1/10 or 0.2 sec) were superimposed on the swell. Wind waves were typically <0.5 ft high.

The original test plan called for the determination of oil recovery by weighing the sorbents after each test. In practice, this method did not produce reliable results due to the excessive and unpredictable water uptake by the sorbent. As the estimated water absorption was about double the original weight of oil spilled, the negative results were not surprising. Table 2 shows the measured weights of oil/water soaked sorbent and the inferred oil recovery weights.

Table 2: Sorbent Weighing Results

Spill #	Spill Type	Total Weight Following Spill (kg)	Pre-Spill Sorbent Weight (kg)	Pre-Spill Oil Weight (kg)	Expected Water Pick-Up (kg)	Derived Oil Recovery Weight (kg)
2	Crude	15.4	6.6	3.0	13.1	-7.4?
3	Crude + BP MA700	13.8	4.6	3.2	9.2	0.0
4	Crude + Corexit 9550	24.2	4.2	3.2	8.3	11.8
5	Crude + Corexit 9527	9.0	3.1	3.1	6.1	-0.2?
6	Crude + BP MA700	15.0	4.3	3.0	8.6	2.0
7	Crude + Corexit 9527	25.0	3.3	3.0	6.6	15.1
8	Diesel + BP MA700	19.9	2.9	3.1	4.8	12.2

Notes:

1. Expected weight of water: 200% sheet or pad weight.
2. All values in kg are ±0.1 kg.
3. Dispersants in water increase water uptake by sorbents.
4. The premixtures of BP MA700 and Corexit 9527 appear to have worked.
5. The sprayed on BP MA700 may have worked.
6. The very large net values indicate that much more dispersant + water has been sorbed than predicted.

Except for Spills #3, 5 and 6, inferred oil recovery weights do not make sense. Clearly the sorption of water in the presence of dispersant, must vary greatly with each test, making the derivation of an accurate oil recovery weight almost impossible.

Water samples were taken during each spill, but there was no way to ensure that the dispersed or undispersed oil in the water column was being sampled. The results of the analyses are presented in Table 3. They indicate that oil had not penetrated to the depth of the sample inlet (1 m) in significant quantities when samples were taken. Without some feedback at the test site, any point sampling will be plagued with significant variability.

Table 3: Water Sample Analyses

Time	Sample	Concentration (ppb)
1330	Control	11
1345	Under 20 litres spill	9
1603	Under 4 litres spill	12
1709	Under 4 litres crude + 0.4 litres BP MA700	7
1803	Under 4 litres crude + 0.4 litres Corexit 9550	12
1905	Under 4 litres crude + 0.4 litres Corexit 9527	27
2040	Under 4 litres crude + <2 litres BP MA700	9
2115	Under 4 litres crude + 0.5 litres Corexit 9527	16
2210	Under 4 litres diesel + 0.4 litres BP MA700	14
2230	20 minutes after last test - water sample	59

The following sections describe each spill in chronological order from neat oil, to the first attempts at spraying dispersant.

Spill #1: 20 Litres Tarsiut Crude Oil

The object of this spill was to see how the spill volume suggested in the test plan behaved before adding dispersants. As the photographs show, the slick did not move away from the stern of the support craft. This may be due to the wind shadow caused by the vessel. Within 15 seconds after oil release the slick was already 5 metres x 5 metres. After roughly 5 minutes the oil which had not already been sorbed started to drift down the boom channel.

Figures 4a/b show the 20 litre oil slick at the beginning and 30 seconds after discharge. The resulting area was far too large to avoid contact with the boomed channel sides, and subsequent spills used only 4 litres of oil.

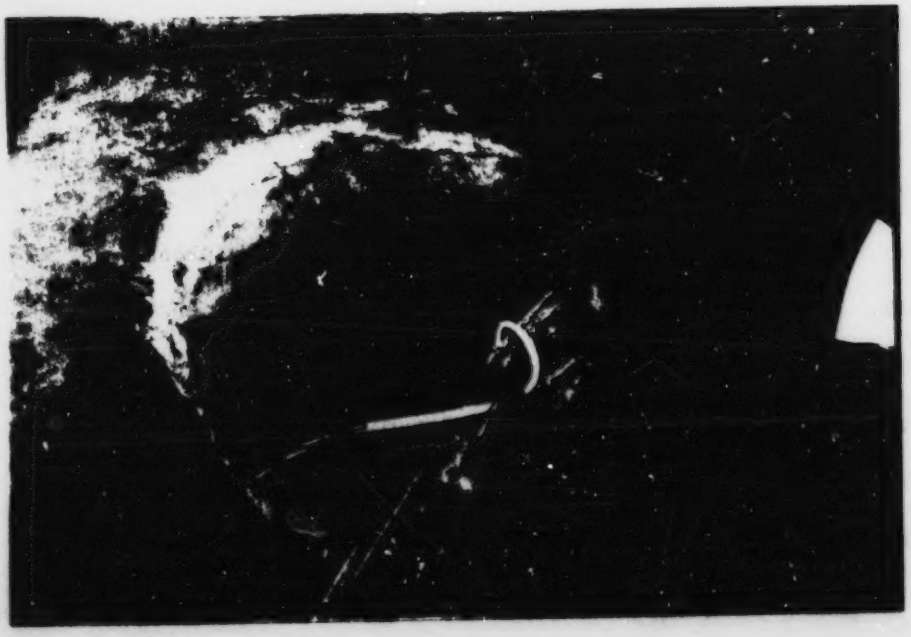


Figure 4a. Start of 20 litre oil slick.

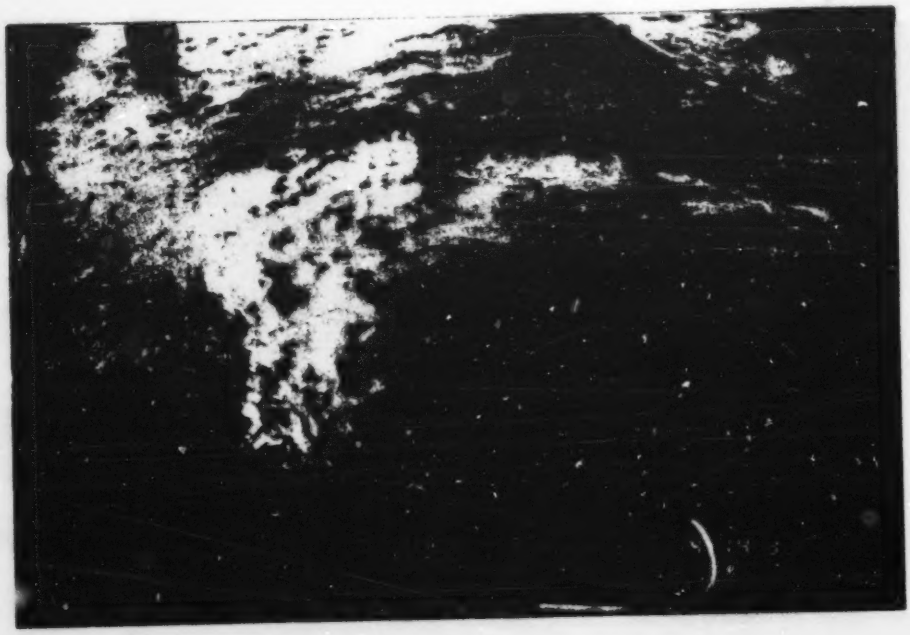


Figure 4b. 20 litre oil slick after 30 seconds.

For this first spill we tried Don MacKay's suggestion that required lacing together sorbent pads to form a multilayer strip with a large absorption surface (see Figure 5).

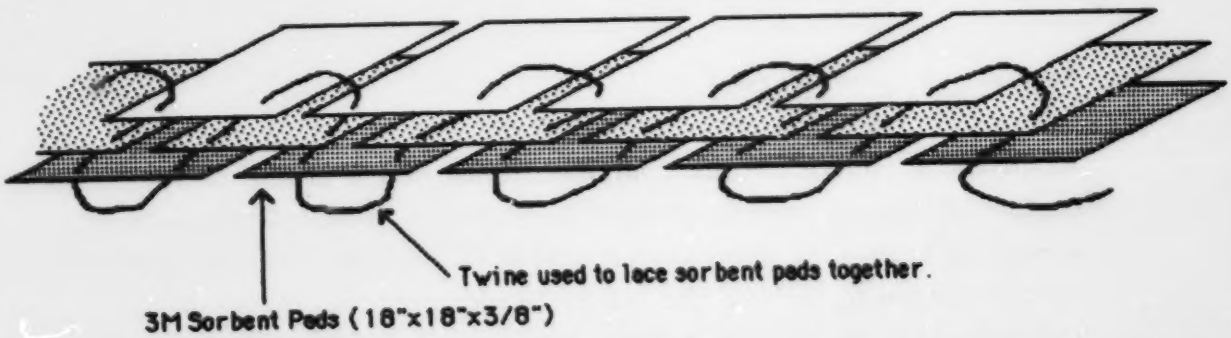


Figure 5. Test section of sorbent pads.

Although this approach spread sorbent across the sorbent boom, it was time consuming to prepare. Subsequent tests used a 6 metre x 1 metre strip cut from a sorbent roll (Figure 6).

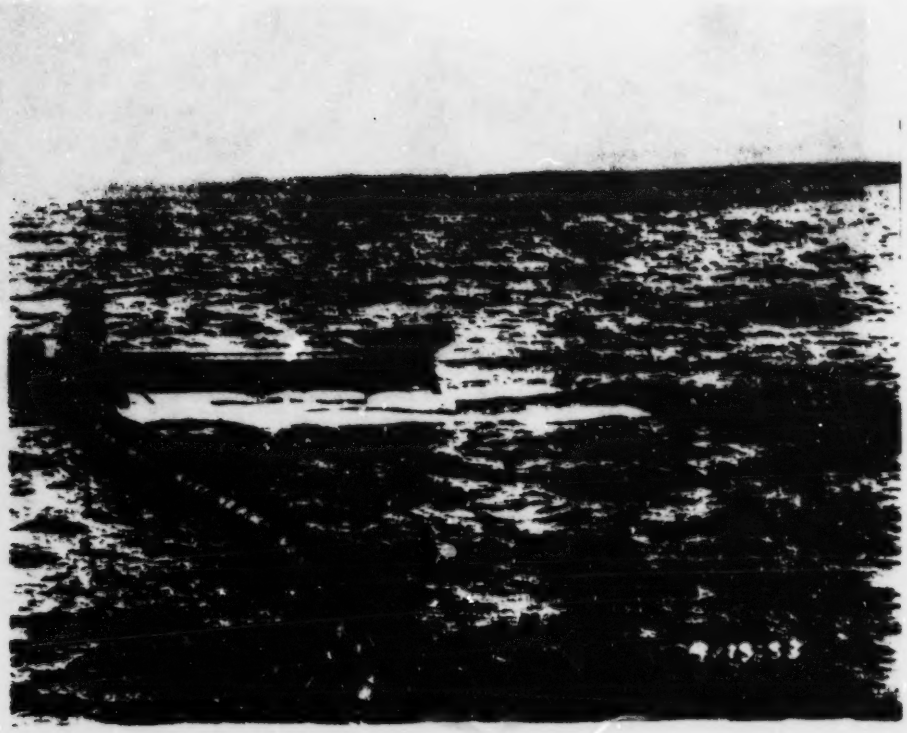


Figure 6. Placing sorbent strips.

Spill #2: 4 Litres Tarsiut Crude Oil (Figure 7)

Again the objective of this spill was to see how a crude oil slick performed before adding dispersant. The 4 litre volume slick spread to a slick no more than 2 metres (6 feet) in diameter, and drifted diagonally across the boom channel, and was bisected by the water sample buoy 2 minutes after release. As photographs were difficult to take beyond the buoy, only the first 8 metres (25 feet) of the channel could be detailed during a spill. After 5 minutes the spill could be detected in two patches roughly 13 metres (40 feet) from the release site. Beyond this point, observers on board the support vessel could not follow the slick until sorbents started to appear black (see Figure 7).

Spill # 2

Date: 4 September 1984
Time of Spill: 1600-1620 hrs.

4L Tarsiut Crude

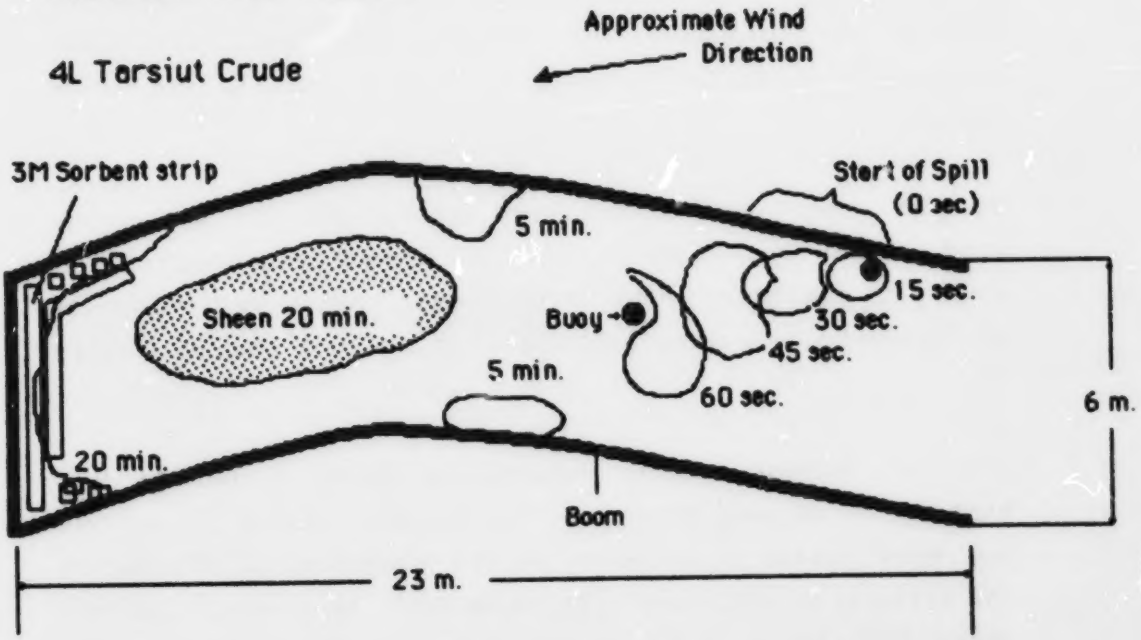


Figure 7. Sketch showing progression of Spill #2.

The slick took approximately 20 minutes to travel the full length of the boom channel. By the time all the sorbent had been collected and weighed another 30 minutes had elapsed. A further 10 minutes were required to spread out another strip of sorbent for the next spill. This resulted in a total cycle time of roughly 1 hour per spill, which is in line with the original two-day test plan calling for 16 to 20 tests.

Spill #3: 4 Litres Tarsiut Crude Oil + 0.4 Litres BP MA700 Premixed

The object of Spills #3, 4 and 5 was to determine if a dispersant to oil ratio of 1:10 would disperse the oil. To optimize the potential for dispersion, the oil and dispersant were mixed together in a bucket before they were poured on the water surface.

The BP premix spill spread very rapidly into and out of the wind. Within 60 seconds the slick had spread to its maximum and started to disappear. After three minutes, only a small volume of oil remained which clung to the sides of the boom channel (Figure 8).

The net sorbent weights reported in Table 3 indicate that virtually no oil was recovered. It is quite difficult to estimate the water uptake of sorbents, as the absorption is affected by the presence of dispersant (Appendix A). Water sample analysis shows high levels of oil in the water column, confirming that significant dispersion occurred in Spill #3.

Due to a delay in setting the sorbent boom, the dispersant was added 40 minutes before the mixture was released. This did not appear to cause any adverse reaction.

Spill # 3

Date: 4 September 1984
Time of Spill: 1700 hrs.

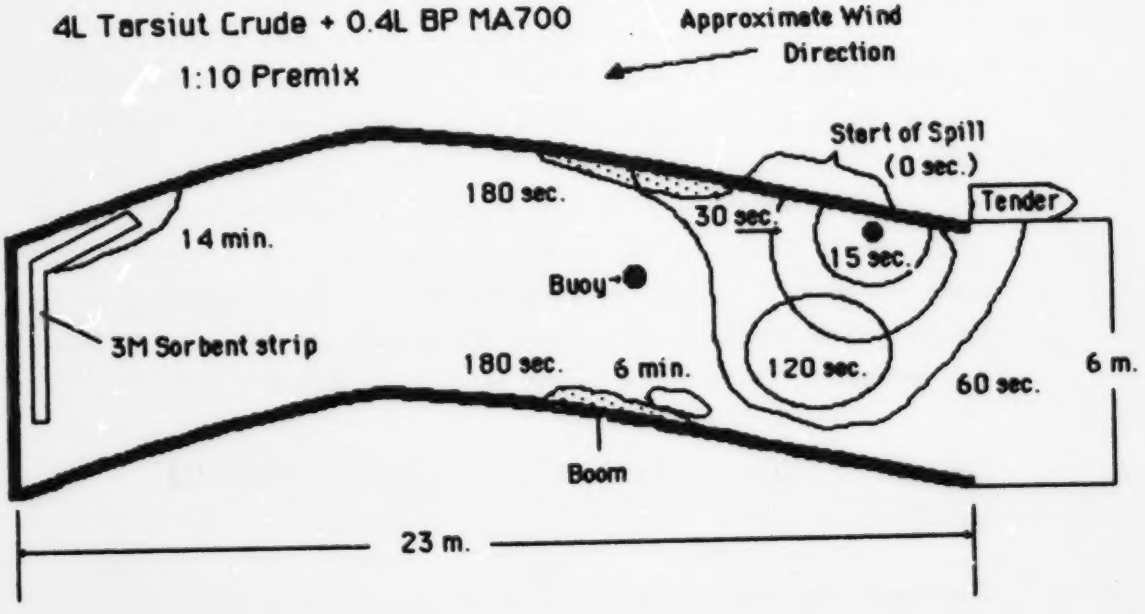


Figure 8. Sketch showing progression of Spill #3.

Spill #4: 4 Litres Tarsiut Crude Oil + 0.4 Litres Corexit 9550 (Premixed) (Figure 9)

This dispersant did not appear to work well. After the premix was added to the water, the slick spread out for roughly 1 minute to reach 3 metres (10 feet) in diameter, and started to drift along the side of the channel with no further dispersion apparent. Figure 9 shows how the slick area spread with time. Observers did observe further dispersion when mixing of the surface occurred during sorbent removal.

Discussions the next day with Mark Bobra indicated that Corexit 9550 may work better with heavier crude oils.

Corexit 9550 was the only dispersant which resulted in resurfacing of the oil. Very thin discs of oil slick 1 to 2 centimetres in diameter started to appear 8 to 9 minutes after the dispersant/oil mixture was released. Further evidence of dispersant failure, is evidenced in Table 3. A large net weight (>5 kg) indicated that some dispersant must be helping the sorbent pick up more water. The presence of excess dispersant in the water column may indicate poor bonding to the oil in a premixed state.

Spill #5: 4 Litres Tarsiut Crude + 0.4 Litres Corexit 9527 (Premixed)

This spill was very similar to Spill #3, using BP MA700. Within 3 minutes the slick had virtually disappeared with only a small amount of oil clinging to one side of the boom channel. After 8 minutes, a brown cloud was visible in the water, roughly half way down the boom channel. The cloud was about 6 metres x 3 metres and appeared to penetrate a metre or more below the water surface. After describing the appearance of the cloud to Mark Bobra, he speculated that it may be caused by dispersant, or perhaps by dispersed oil. The spread of the slick is shown in Figure 10.

Spill # 4

Date: 4 September 1984
Time of Spill: 1800 hrs.

4L Tarsiut Crude + 0.4L Corexit 9550

1:10 Premix

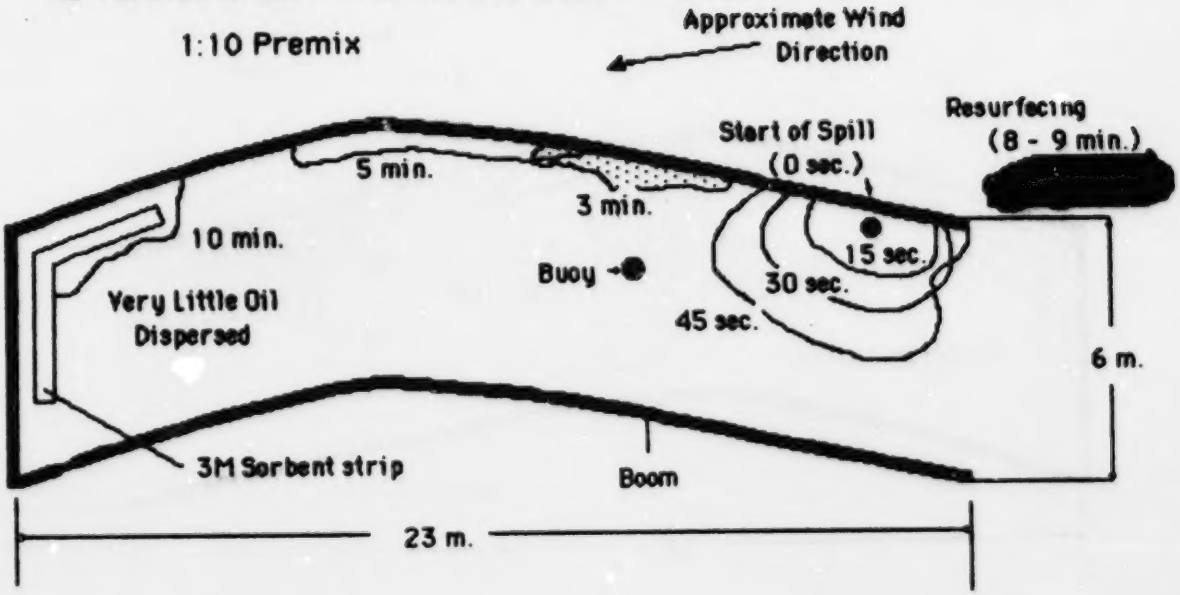


Figure 9. Sketch showing progression of Spill #4.

Spill # 5

Date: 4 September 1984
Time of Spill: 1900 hrs.

4L Tarsiut Crude + 0.4L Corexit 9527

1:10 Premix

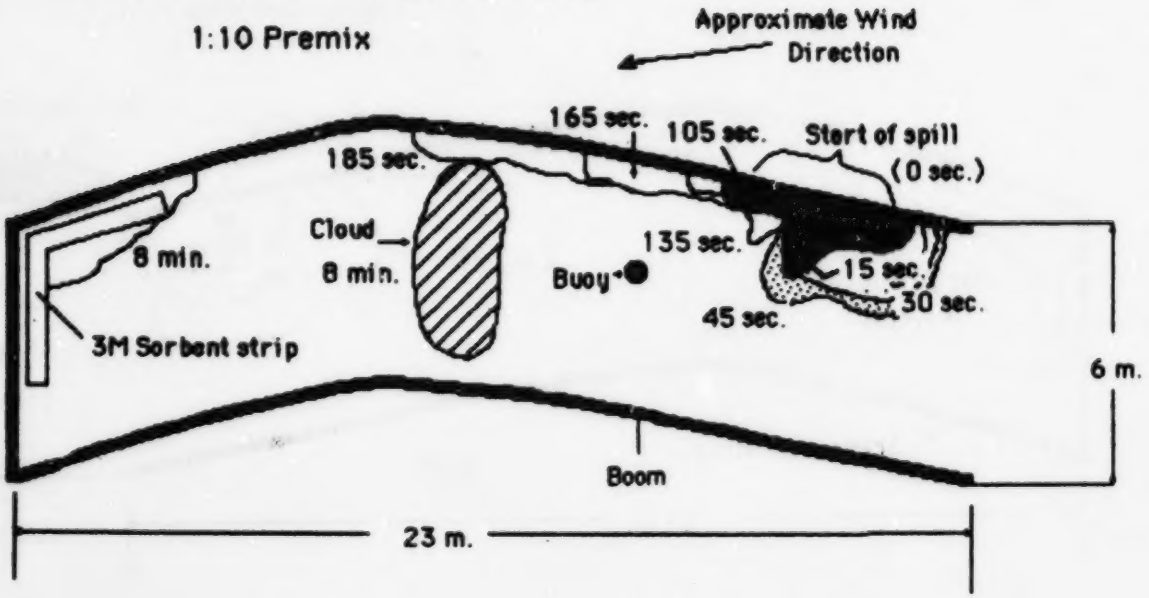


Figure 10. Sketch showing progression of Spill #5.

Spill #6: 4 Litres Tarsiut Crude + 0.5 to 1.5 Litres BP MA700 (Sprayed)

The object of this spill was to determine the effectiveness of spray application with dispersants and to give native people experience in applying dispersants.

When the herbicide sprayer was used to dispense the dispersant, we were unable to obtain a mist due to the high viscosity of the dispersants. We later learned from M. Bobra that the dispersants could be diluted with water without adverse effects upon the dispersant's properties. Another problem which was encountered, was the short length of flexible hose for spraying. This resulted in the hose becoming disconnected, and an unknown volume of dispersant was lost in the bottom of the boat. The actual volume of dispersant applied to the oil is thought to be between 1.3 litres and 2.6 litres.

Figure 11 shows how the slick spread. Because a sprayer could not dispense the full volume of dispersant immediately, the rapid dispersion observed in the premix spill was not expected. Dispersion did occur when the dispersant contacted the oil. The thinning of the slick was most obvious between 2 and 3 minutes. Another indicator of dispersion was the upwind spreading of the oil even after 95 seconds.

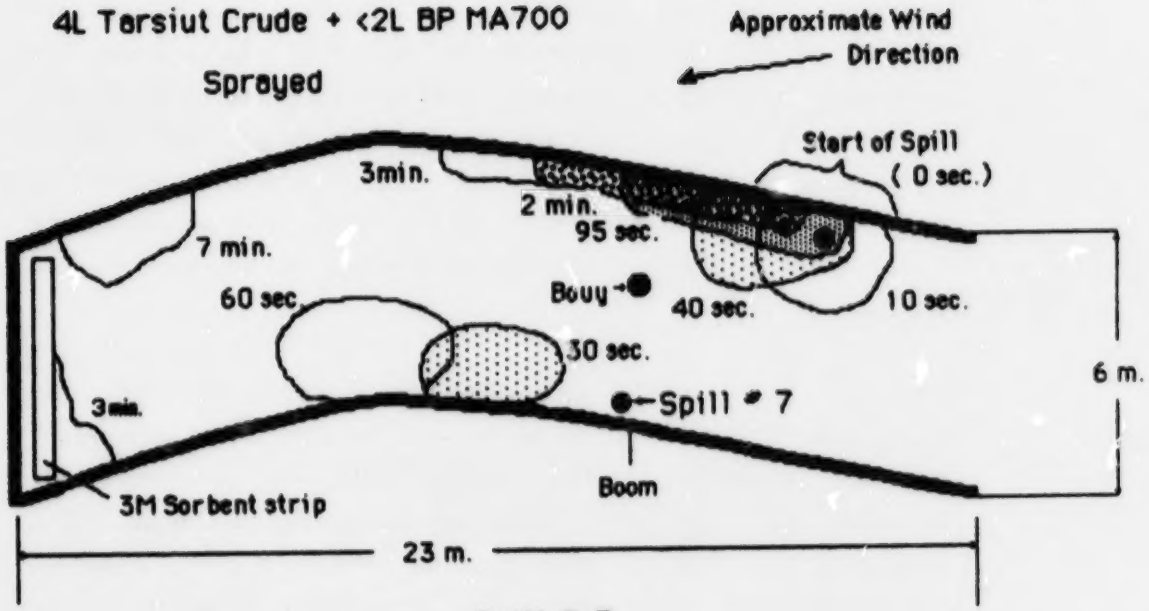
It is very difficult to tell if the 2 kilogram net weight calculated for Table 3 indicates that 1/3 of the oil was dispersed, or that the estimate of water uptake was incorrect due to BP MA700 not significantly altering the water uptake by sorbents.

Spill # 6

Date: 4 September 1984
Time of Spill: 2000 hrs.

4L Tarsiut Crude + <2L BP MA700

Sprayed



Spill # 7

Date: 4 September 1984
Time of Spill: 2100 hrs.

4L Tarsiut Crude + 0.5 L Corexit 9527

Sprayed

Figure 11. Sketch showing progression of Spills #6 and 7.

Spill #7: 4 Litres Tarsiut Crude + 0.5 Litres Corexit 9527 (Sprayed)

Corexit 9527 appeared to disperse oil on contact, but did not cause any upwind spreading of the oil slick. The volume of oil recovered was masked by the extra water absorption which resulted from spraying dispersant on the boom. Visual estimation indicates that up to 50% of the oil may have been dispersed.

One of the problems associated with the late night tests was a lack of sufficient light to use a polarizing filter to remove glare. Without the filter, photographs of oil on water do not show the oil clearly. This problem affected the last two spills in particular.

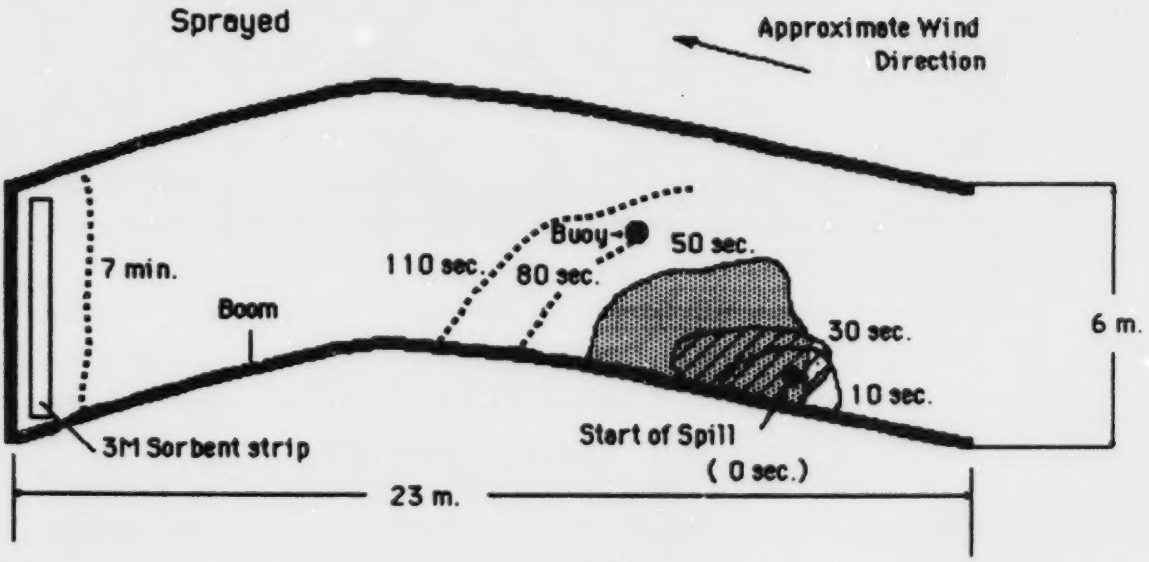
Spill #8: 4 Litres Diesel Oil + 0.4 Litres BP MA700 (Sprayed) (Figure 12)

This spill was not started until after 2200 hours, by which time one could barely take photographs using 400 ASA film. Also, the diesel fuel was virtually invisible against the brownish Mackenzie River discharge. An estimate of the slick spreading was made by following bubbles, which formed when BP MA700 was sprayed onto the diesel oil. Only BP MA700 was tried, as it appeared to be the most effective dispersant. Future tests using diesel oil should either dye the oil, have a precise measure of oil recovery or at least be conducted in clear water, with excellent natural light.

Spill # 8

Date: 4 September 1984
Time of Spill: 2200 hrs.

4L Arctic Diesel + 0.4L BP MA700



Broken lines indicate that the edge of the slick area has been estimated.

Figure 12. Sketch showing progression of Spill #8.

4.0 RECOMMENDATIONS AND CONCLUSIONS

It is possible to use a boomed channel for containing small oil spill experiments. The boom should be anchored at the downwind ends, with the upwind ends anchored or attached to spreaders if they are available. Swells in excess of 1 metre cause the boom to roll excessively. The use of a sorbent boom at the downwind end of the channel successfully prevented any oil from escaping the test area (confirmed by aerial observations).

Another major result was that dispersants do work on Tarsiut crude oil in the Beaufort Sea. Further studies are required before an application technique can be evaluated. Any future use of the backpack type herbicide sprayers will require experimenting with dispersant/water mixtures to attain the desired spray characteristics. Also, roughly 2 metres of flexible hose should be added to avoid the risk of disconnection and to make the sprayer operation easier.

The major failure of the study, was the technique for measuring oil recovery. Simple weighing worked reasonably well until dispersants were used. Future work will need to develop a system which wrings out the sorbents and then separates the oil from the water. This procedure would be possible with a larger support vessel and additional field personnel.

If possible, future studies should try to release the oil more than one slick diameter away from the edge of the boom channel. Once slicks were close to the sides of the boom channel, they tended to stay there. This resulted in lower slick drift velocities than would ncrmally be expected.

Qualitatively, the BP MA700 appeared to cause the most rapid and complete dispersion of Tarsiut crude oil. Corexit 9527 was as effective, but seemed to take longer. Corexit 9550 is not

recommended for application to Tarsiut type crude oils, because of oil resurfacing. Corexit 9550 was not an effective dispersant under the conditions tested.

Several operational comments are included here to avoid some of the frustrations experienced in this test.

1. Communications between the vessel and aircraft, or between the vessel and shore would ensure that essential personnel arrive on site without unnecessary delay.

2. Additional lead time would enable necessary approvals and permits to be obtained in advance, without jeopardizing the field program through unpredictable changes in schedule.

3. Extra sorbent should be stockpiled on shore and brought to the site as needed. Inadequate sorbent was on hand to complete the experiment as planned.

4. Spills should take place in daylight hours to enable detailed observations and photography.

5. A minimum of six days is required to ensure successful completion of a two day arctic test (allowing for deployment, clean-up, and weather problems).

6. In situ measurements of oil concentration should be taken to ensure that meaningful samples are collected.

ACKNOWLEDGEMENTS

The author wishes to acknowledge the assistance of the employees of Beaufort Environmental Support Services in the measurement of scientific data. Although Don MacKay and Mark Bobra from the University of Toronto were unable to attend the demonstration, their guidance and information was essential to the planning and execution of the demonstration. The cooperation of the Environmental Protection Service regional offices in Vancouver and Whitehorse (Steve Pond and Doug Kittle respectively) ensured that the necessary permits and approvals were obtained.

LIST OF PARTICIPANTS

Prime Contractor:	Don MacWatt Beaufort Environmental Support Services
Specialist Consultants: **Scientific Observers**	Anthony Dickinson D F Dickins Associates Ltd.
	Don MacKay Mark Bobra University of Toronto, Department of Chemical Engineering
Government Representative on Site:	Doug Kittle Department of Environment, Environmental Protection Service, Whitehorse

APPENDICES

A. Calculation of Water Absorption by Sorbents

B. List of Water Samples Collected

C. Proposed Experimental Flow Chart

D. Example Data Collection Sheet

E. Correspondence

APPENDIX A - SORBENT UPTAKE

Calculation of Water Uptake by Sorbents: Controls

Type of Sorbent	Volume of Sorbent	Weight Before (kg)	Weight After (kg)	Weight of Water as a % of Sorbent Weight (%)	Density of Sorbent kg/m^3
Roll	20' x 3' x 3/8"	2.35	/		44
Pads	30-18" x 18" x 3/8"	2.5 kg/30			42
	9-18" x 18" x 3/8"	0.75 kg/9	2.2 kg/9 (3 hrs both sides)	200	42
Boom	1-10' x 8" dia.	4	4.9 (1 hr)	22.5	/

Uptake of Oil and Water by Sorbents: Experimental

Type of Sorbent	No. Used	Weight Before (kg)	Weight After (kg)	Spill #	Time in Water (hrs)
Boom	2	8.25	15.1	1,2,3	5
Boom	2	7.4	9.6	4	1
Recycled Boom	2	9.6	10.2	5	1.5
Recycled Boom	2	10.2	10.8	6	3
Boom	2	7.6	15.7	7	0.75
Recycled Boom	2	15.7	32.5	8	1.5

Data from Alfred Chau[2]

Uptake of Water by Sorbent (18" x 18" x 3/16" - 3M Type)

Time (min)	Weight Before (g)	Weight After (g)	Weight of Water as a % of Sorbent (%)	Comments
0	28.3	28.3	0	
3	28.3	30.1	0.064	Experiment to measure the effect of time upon the uptake of water by sorbents
6	28.3	31.5	0.113	
9	28.3	32.7	0.155	
12	28.3	33.5	0.184	
15	28.3	34.5	0.219	
30	28.3	34.7	0.226	
45	28.3	35.0	0.237	
60	28.3	34.8	0.230	

Weight of Dispersant	(Corexit 9527 1 hour)	Weight of Water as a % of Sorbent	Comments
0		0.138	Experiment measures effect of dispersant upon water uptake by sorbents
3.2		0.677	
4.3		0.975	
32.5		5.32	

Water Salinity	Weight Oil	Weight Dispersant	Sorbent Weight Before	Sorbent Weight After	Comments
0%	0	0	29.65	33.3	
	51.9	0	29.65	60.4	
	0	35	28.8	182	Experiment to show effect of salinity upon water uptake by sorbents
3%	0	0	27.8	32.1	
	52.3	0	27.8	60.8	
	0	32.5	28.0	176.7	
	51.95	3	28.05	79.0	
	0	4.3	28.0	55.3	
	6?	3.2	28.65	58.7	

Notes:

1. All three tests used the dispersant Corexit 9527 and 3M 18" x 18" x 3/16" type sorbent pads
2. Alfred Chau is a Research Assistant at the University of Toronto, Department of Chemical Engineering

APPENDIX B

LIST OF WATER SAMPLES COLLECTED

SAMPLE	DESCRIPTION
1	Control - Taken before any oil was spilled
2	Sample taken under 20 L spill
3	Tarsuit Crude
4	Sample taken under 4 L spill
5	Sample of BP MA700
6	Under 4 L crude + 0.4 L BPMA700
7	" + 0.4 L Corexit 9550
8	" + 0.4 L Corexit 9527
9	Sample of Corexit 9527
10	Under 4 L crude + 2 L BPMA700 sprayed
11	Sample of Corexit 9550
12	Under 4 L crude + 0.5 L Corexit 9527 sprayed
13	Under 4 L diesel + 0.4 L BPMA700 sprayed
14	20 minutes after clean-up of last spill

APPENDIX C

PROPOSED EXPERIMENTAL FLOW CHART

SMALL SCALE BEAUFORT SEA DISPERSANT DEMONSTRATION

AUGUST - SEPTEMBER 1984

for

Environmental Protection Service
Whitehorse, Yukon

Prepared by: David Dickins
Anthony Dickinson
Don Mackay

SMALL SCALE BEAUFORT SEA DISPERSANT DEMONSTRATION

Tentative description of test schedule. These tests may subsequently be modified to account for field conditions.

PURPOSE AND DESCRIPTION OF DEMONSTRATION

1. Boom Deployment

. **Purpose:** is to determine floating configuration of boom relative to wind and waves

. **Ideal:** 4 m to 6 m width , 40 m to 50 m length

2. Test Patch

2 tests -
one marine diesel
one B.S. crude

. **Purpose:** to see if boom configuration is large enough to contain thin oil slick

: also test effectiveness of sorbent

* take control samples of water before oil spilled, of water under oil, and of straight crude and diesel

3. Dispersant Addition
(BP MA7000) +
(crude)

. **Purpose:** try several dilutions starting with 1:10 to find the largest ratio at which dispersant will operate (try ratios in multiples of 5, i.e. 1:5, 1:10)
- mixture to be well mixed before adding to water (shake and stir)

* BP MA7000 sample
* take photographs
* take water sample within dispersed oil

SMALL SCALE BEAUFORT SEA DISPERSANT DEMONSTRATION

4. Comparison of Dispersants
Corexit 9550

. **Purpose:** try several dilutions of Corexit, starting with largest ratio that worked for BP MA7000
- mix well before adding to water
* take a water sample and a Corexit sample
* take photographs

5. BP MA7000 + Diesel Fuel

. **Purpose:** premixing several dilutions of dispersant. starting with largest ratio that worked for crude oil
* sample under slick
* take photographs
* observe differences between diesel and crude

6. Corexit + Diesel Fuel

. **Purpose:** same as 5. except different dispersant

SMALL SCALE BEAUFORT SEA DISPERSANT DEMONSTRATION

7. Spray Application . **Purpose:** test portable back pack spray units to apply dispersant to the oil slick inside boomed area

test sequence:

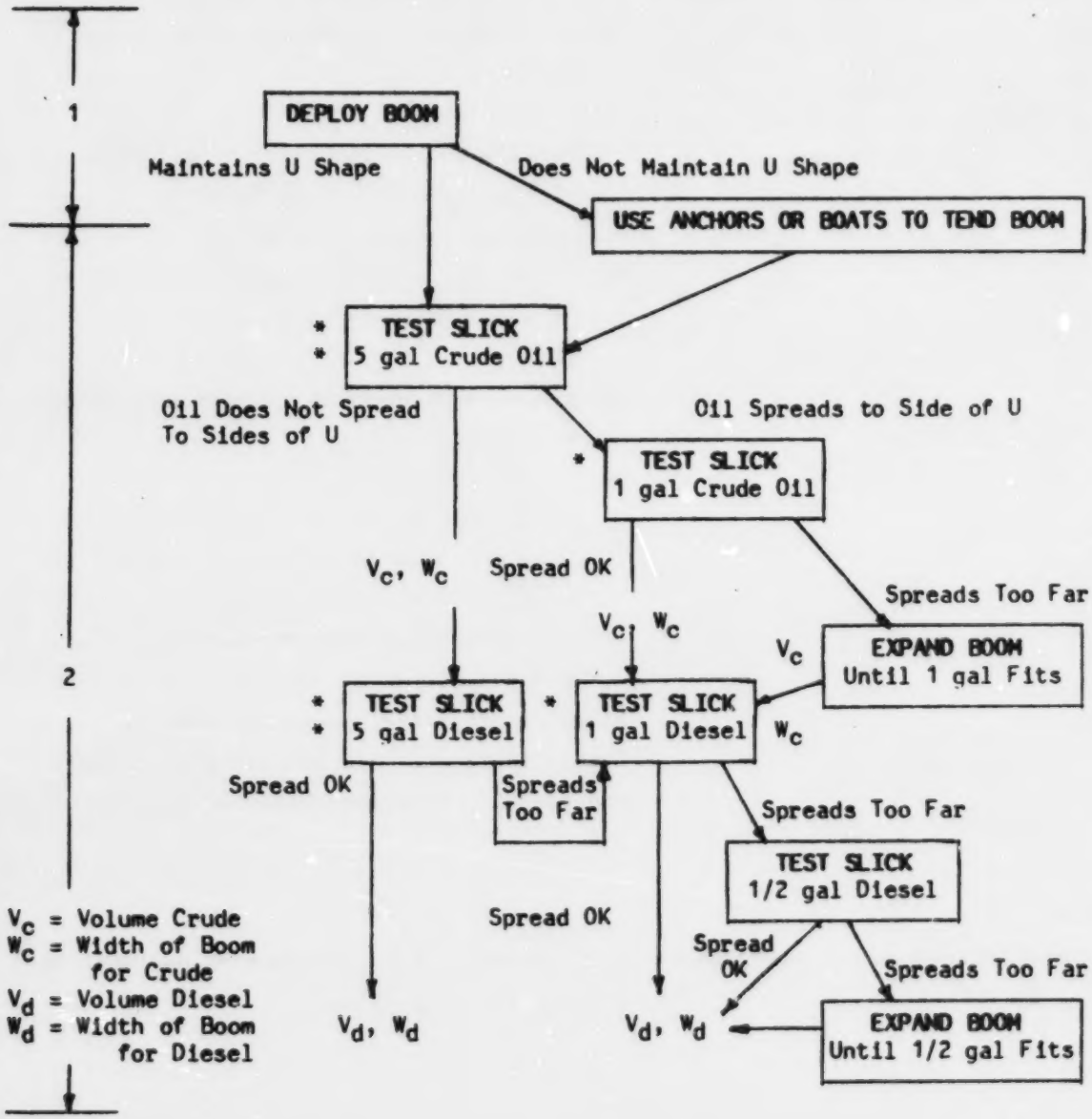
a. position boats each side of oil boom with spray booms (hand held)
b. spill up to 5 gallons of oil
c. follow oil slick and spray on specified volume of dispersant, 0.25 to 1.0 gallons
d. agitate with paddles if necessary to add wave energy
e. sample water under slick
f. photograph at regular time interval
g. clean off boom as necessary; collect and weigh sorbent

Note: spray tests will be carried out at up to 3 dilutions (as high as 1:5) if necessary to achieve positive results. Both dispersants will be used with crude and diesel. Probable number of tests - 8

8. Esso Spray Boom . **Purpose:** last resort if hand sprayers do not achieve significant dispersion

SMALL SCALE BEAUFORT SEA DISPERSANT DEMONSTRATION

FLOW CHART FOR DISPERSANT DEMONSTRATION

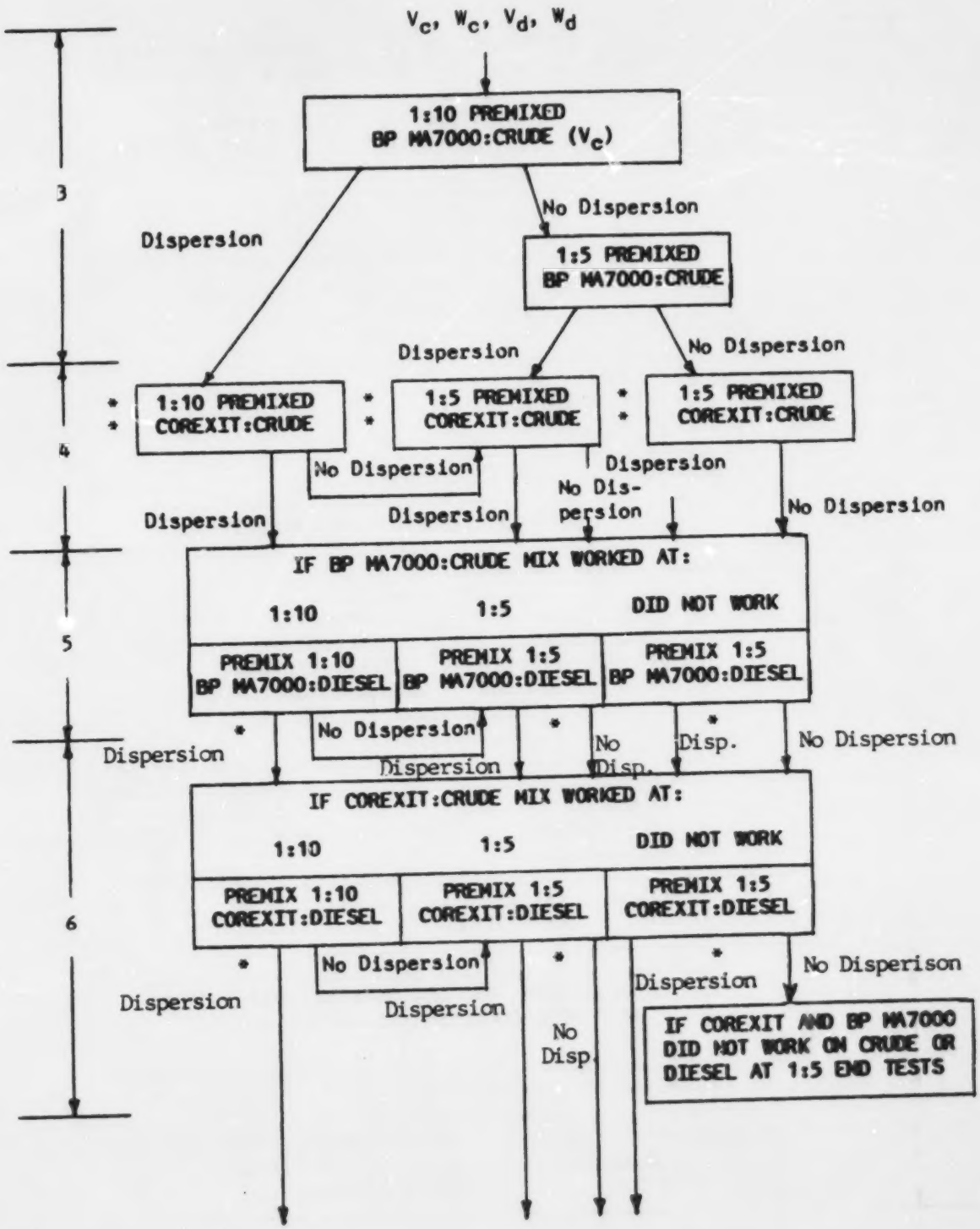


* Take Water Sample

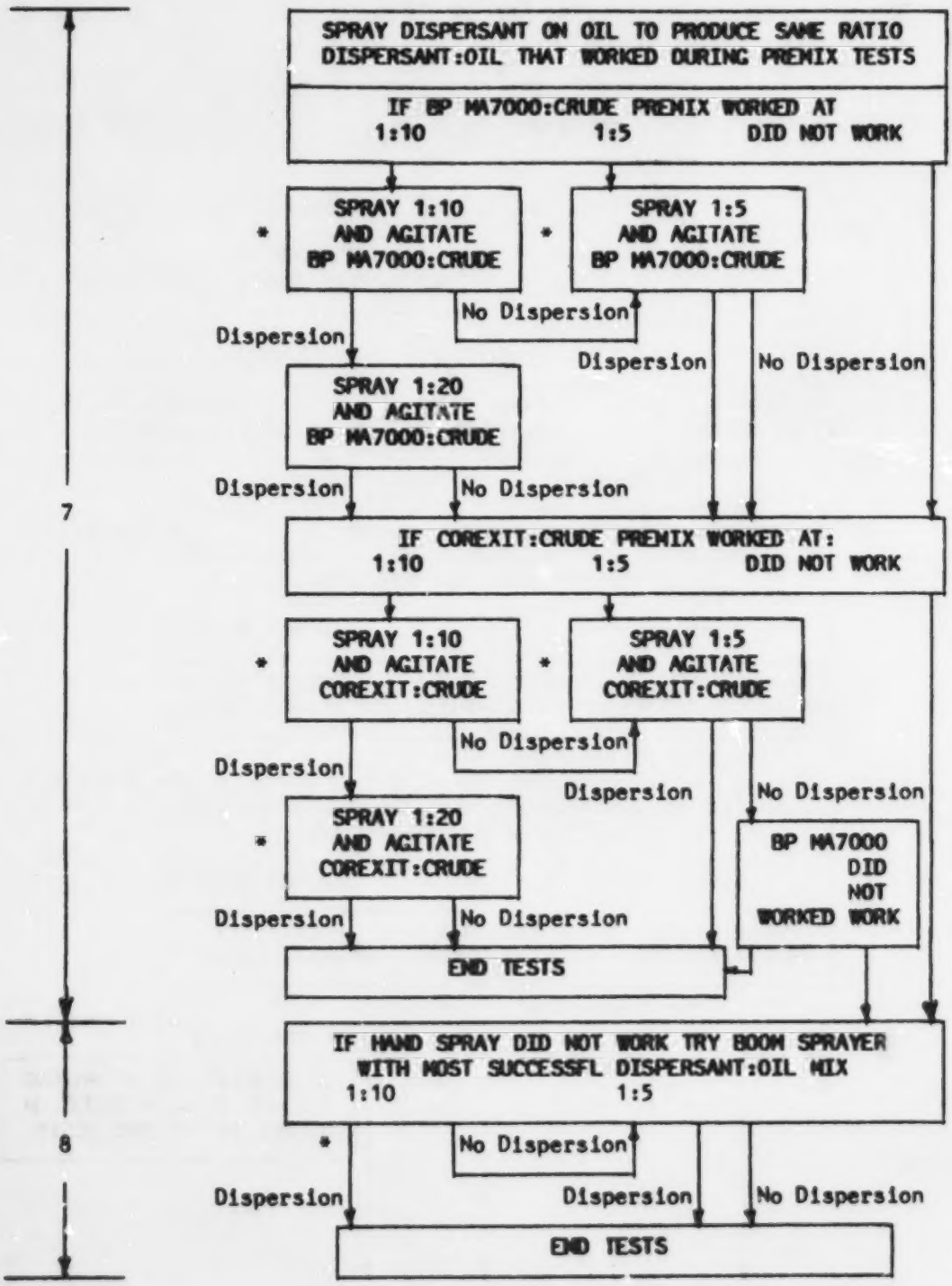
* Take Oil Sample

* Take Dispersant Sample

SMALL SCALE BEAUFORT SEA DISPERSANT DEMONSTRATION



SMALL SCALE BEAUFORT SEA DISPERSANT DEMONSTRATION



SMALL SCALE BEAUFORT SEA DISPERSANT DEMONSTRATION

FIELD MEASUREMENT LIST

Air Temperature	. before each demonstration
Wind Speed/Direction	. before each demonstration
Current Speed/Direction Within Boomed Area	. periodically
Water Temperature	. start and end of demonstration period
Oil/Dispersant Temperature	. if different from ambient
Oil Samples	. one of each type
Dispersant Samples	. one of each type
Water Samples	. one for salinity
	. one during each test using tube drawings from predetermined depth 10 cm to 60 cm depending on sea state
Slick Volume	. logged before each spill
Slick Area	. from photographs and video
Dispersant Volume	. logged before added to oil or sprayer
Sorbent Appearance	. photograph after each test
Sorbent Weight	. measure with hanging scale after each demonstration
Wave Height/Wave Period	. periodically if possible

APPENDIX D - EXAMPLE DATA COLLECTION SHEET

OPERATORS:

DATE _____
TRIAL _____

WEATHER:
WIND SPEED:
DIREC:
TEMP:

OIL TYPE:
VOLUME:

WATER TEMP:
CURRENT:
DIRECTI:
WAVE Ht:
PERIOD:

DISPERSANT TYPE:
VOLUME:
ADDED AT:

SLICK SHAPE:
SIZE:
DIRECTION OF SLICK DRIFT:

	CONTROL	EXPERIMENT
SORBENT WEIGHT- BEFORE:		
AFTER:		

COMMENTS:

SKETCH OF BOATS AND SLICK PROGRESSION WITH RESPECT TO TIME:

APPENDIX E

SOME THOUGHTS ON THE BEAUFORT SEA SPILL

by

Don MacKay

A major contribution of the work will be to determine if dispersant effectiveness can be measured at the sea surface with the double boom system. If it works it may set a pattern for future spills. Early on it may be wise to test how the booms align themselves. Do they come together? or spread?

What is a good separation to get them to lie properly? I think that we are looking at 4 to 6 yards or metres.

I would favour spilling several small batches of oil, say 5 gallons or 20 litres at a time. If the oil spreads out over a 5 metre x 5 metre area (25 m^2) and has a volume of 20 litres or 0.02 m^3, it will have a thickness of 0.02/25 = 0.001 m = 1 mm which is quite nice.

We did some tests with the sorbent. A base of sorbent of area 100 cm^2, i.e. 10 cm x 10 cm will pick up a maximum of 30 cm^3 of oil, but we may be lucky to get 10 cm^3. If we spill 20 litres or 20,000 cm^3 this implies having an area of

$$20{,}000 \times \frac{100}{10} = 200{,}000 \text{ cm}^2$$

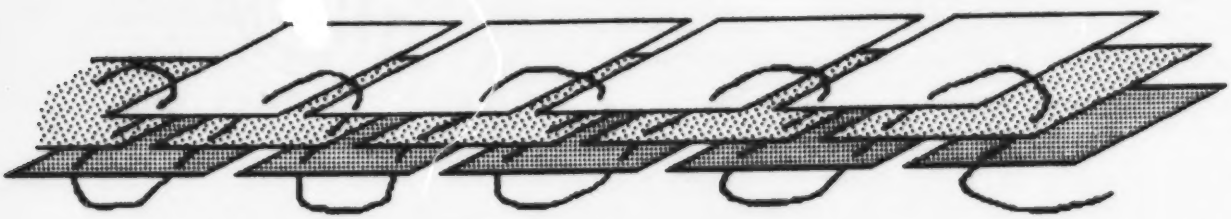
or

$$\frac{200{,}000}{100 \times 100} \text{ or } 20 \text{ m}^2 \text{ or sorbent.}$$

The sorbent pads are 18 inches square or about 1/4 of a square metre, thus we may need about 80 pads 18" x 18".

If the boom is 5 m apart, we could do this by having the pads in several layers like a sandwich, side by side with say 15 side by side with 3 deep and two booms at 5 deep.

I tried out a system like this with a polypropylene rope fed through holes as shown. It worked quite well and lay nicely on the water, i.e. in plain view.



You should be prepared to weigh quite a lot of sorbent. It may be good to have two booms with the second for safety.

We find that the booms do take up some water -- about 20% of their weight maximum. It will require trial and error.

I would suggest a spill of oil alone first. See how it behaves. Does it stick to the booms or does it flow down the channel? Try to collect it. Does it work? What is the weight measure of the sorbent boom? Does it gibe with the weight of oil? Does oil escape? Do the booms pick up water? Lots of photos and videotapes. How fast does the oil move? Record temperature, wind. Keep oil sample, etc.

Then mix 1 volume dispersant and 10 volumes oil and spill it carefully on to the water surface. Don't mix it into the water. What happens? Does sorbent boom pick up any? Is water murky with oil? Take water samples.

If complete dispersion, repeat with 1 part dispersant to 20 parts of oil. Photos, etc. If no significant dispersion, repeat with 1:5. Try other dispersants. Try mixing with paddles or trolling motor.

The aim should be to get the dispersant to work under some condition then compare dispersants approximately and define under what conditions they do work.

Then try spraying the dispersant on to the oil and see if this works.

If you have bright ideas during the trial, try them! Keep the observations simple and reliable -- no fancy instruments.

If you spray dispersant try to get the spray as fine as possible. Keep the nozzle just in case we want to measure the spray drop size.

- Don MacKay

APPENDIX F

Laboratory Effectiveness Test of Dispersants on Tarsiut Crude Oil

A series of laboratory tests using the MNS Apparatus was conducted to evaluate the performance of three chemical dispersants (BP MA700, Corexit 9527 and Corexit 9550) on the Tarsiut Crude Oil under the following conditions, which, it is hoped reproduce to some extent the Beaufort Sea conditions.

Temperature: 5°C ± 1°C

Water salinity: 33 ppt.

Pressure drop: 21 cm water across the orifice plate

Experimental

Figure 1 shows the diagram of the MNS Apparatus. In each run, 6 litres of synthetic seawater of desired salinity was added to the clean vessel which was contained in a temperature controlled bath. After the seawater reached the desired temperature, the lid was fitted and the containment ring was lowered until it was half immersed in water. The air flow was then turned on and regulated to produce a pressure drop across the orifice plate which corresponded to the desired turbulence level. After a steady wave motion had developed, 10 mL of crude oil was added to the water surface inside the containment ring. Dispersant was then delivered dropwise onto the oil surface from a digital pipette. A minute and a half after applying the dispersant onto the oil surface, the containment ring was lifted. After 10 minutes of

agitation, a 500 mL sample was taken and analyzed for oil content and hence the percent oil dispersed is calculated. The test was repeated with various amounts of dispersant to yield a plot of percent oil dispersed versus dispersant-to-oil ratios. The amount of dispersant necessary to disperse 50% of the oil can then be deduced. This is accepted as an indication of the effectiveness, a low D/O ratio being better than a high D/O ratio value.

The specific gravity and viscosity of the Tarsuit crude oil measured at 5°C were 0.8780 and 12.2 cp respectively.

Results and Discussion

The results are given in Table F1 and Figure F1. The laboratory conditions differed significantly from the sea tests in that the dispersant-to-oil ratios were lower ie 1/200 to 1/30 compared to 1/10 at sea. Further, the dispersant was added to the oil rather than premixing. Corexit 9527 and MA700 were very effective. Corexit 9550 was less effective, but it is designed to perform best on viscous oils.

These results are in qualitative agreement with those obtained during the sea tests which suggests that the MNS test can be used to discriminate between effective and ineffective dispersants. It is unlikely that there is significant discrimination between products such as Corexit 9527 and MA700 which are both effective. It is suggested that in any future test program a parallel laboratory program be undertaken in the hope of building up further information linking laboratory and sea effectiveness.

Table 1: Effectiveness Test Results of Dispersants on Tarsuit Crude Oil

	Dispersant-to-Oil Ratio					
Dispersant	0.0050	0.0100	0.0150	0.0200	0.0250	0.0300
Corexit 9550	19.22	18.80	31.21	33.08	33.76	25.56*
		27.74		41.33		
Corexit 9527	29.54	56.32	56.98	66.63	70.42	52.96*
	34.57	47.50	76.46	60.27	69.25	
bP MA700	23.41	32.27	51.14	57.38	46.64*	43.14*
	25.08	42.20	31.21	59.17		
			44.88			

* wave damping occurred thus the reported values are low

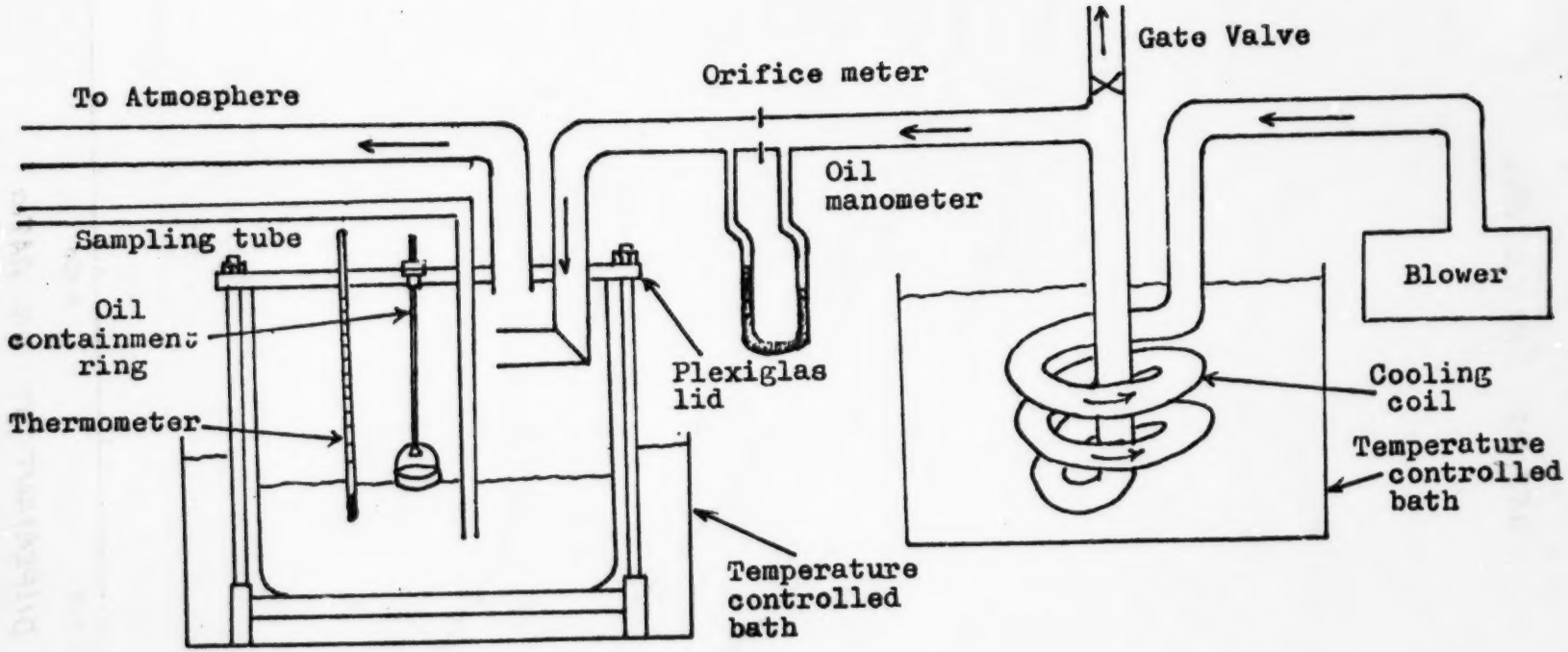
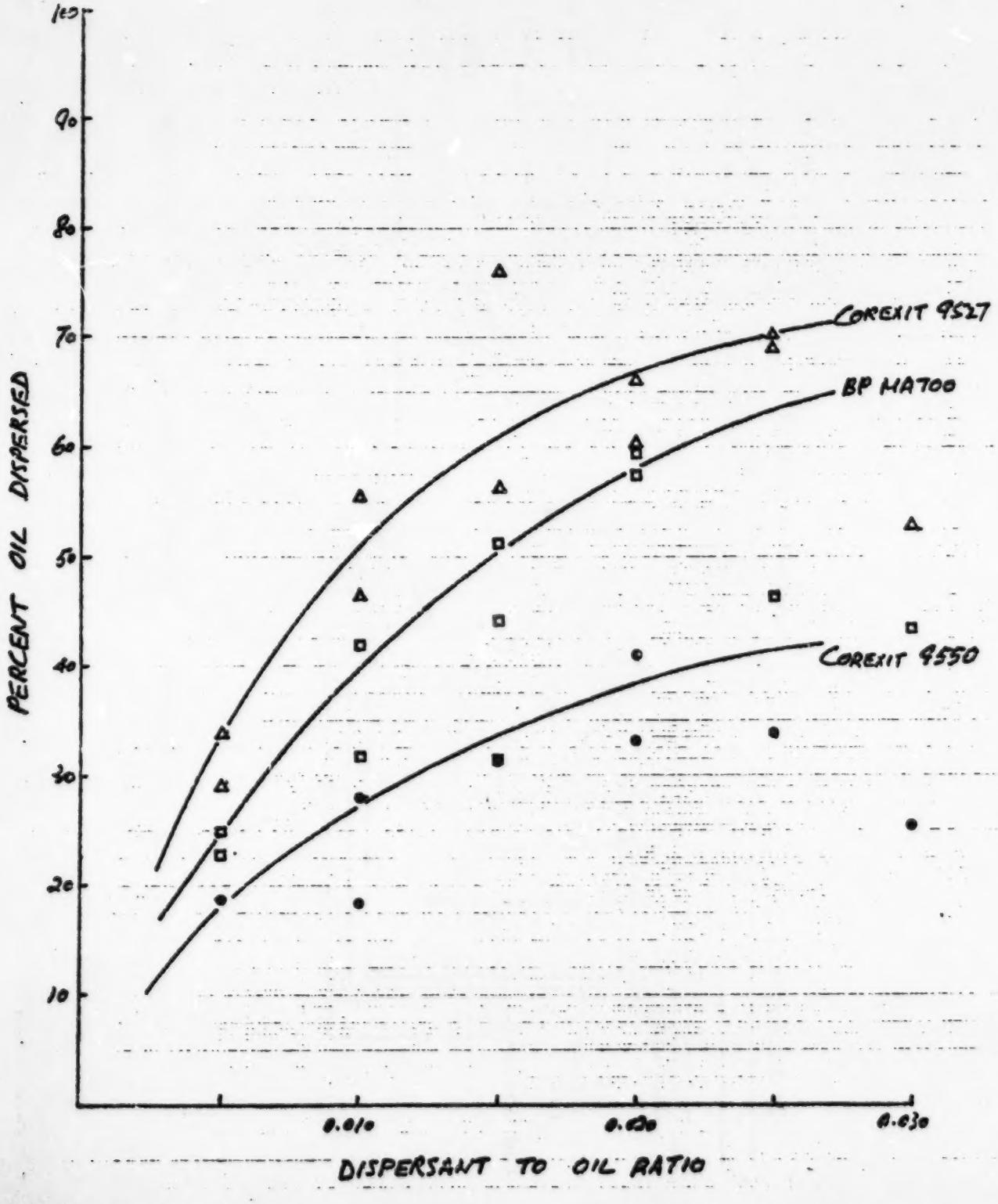


Figure 1. Schematic Diagram of MNS Apparatus

FIGURE 2 : DISPERSANT EFFECTIVENESS ON THE TARSIUT CRUDE OIL



Appendix G

Some Views on the Results - D. Mackay

The use of a boomed channel for conducting small oil spill experiments in a fully contained configuration has been demonstrated. Certain improvements in technique could be made. The boom should be anchored at the downwind ends, with the upwind ends anchored or attached to spreaders if they are available. Swells in excess of 1 metre cause the boom to roll excessively. The use of a sorbent boom at the downwind end of the channel successfully prevented any oil from escaping the test area (confirmed by aerial observations).

Some better method of quantifying the oil in the sorbent is needed. Perhaps the oil could be extracted by solvent or detergent or the sorbent could be dissolved or destroyed. A wringer or wine press may be suitable. An alternative would be to deploy a section of flow-boom (BP type) to skim the oil from the water surface.

If possible, future studies should try to release the oil more than one slick diameter away from the edge of the boom channel. Once slicks were close to the sides of the boom channel, they tended to stay there. This resulted in lower slick drift velocities than would normally be expected.

It may be desirable to discharge the oil into the centre of the spill area and possibly do so continuously at a low flow rate for a period of some 10 minutes. This would enable steady state conditions to be reached. Dispersant would then be added continuously or intermittently.

It was demonstrated that dispersants do work on Tarsiut crude oil in the Beaufort Sea. Laboratory results were consistent with the field observations. Further studies are required before an application technique can be evaluated. Any future use of the backpack type herbicide sprayers will require experimenting with dispersant/water mixtures to attain the desired spray characteristics. Also, roughly 2 metres of flexible hose should be added to avoid the risk of disconnection and to make the sprayer operation easier.

Qualitatively, the BP MA700 appeared to cause the most rapid and complete dispersion of Tarsiut crude oil. Corexit 9527 was as effective, but seemed to take longer. Corexit 9550 is not recommended for application to Tarsiut type crude oils, because of oil resurfacing. Corexit 9550 was not an effective dispersant under the conditions tested, but it may be suitable for heavier crude oils.

It is concluded that the concept of the boomed channel experimental spill has a number of significant advantages as follows

(1) The surface oil is contained at all times thus concerns of contamination of the area are allayed. This may make for easier regulatory approval.

(2) It may be feasible to do more spills of different oils and dispersants at different application ratios and sea-states. The large spills tend to be few in number.

(3) The cost of each test is much less than a full scale test of the Halifax 1983 type.

(4) If the surface oil recovery technique could be perfected the test would give an unequivocal determination of percentage of oil dispersed. It is probably impossible to determine this number accurately by taking water samples.

(5) In some respects the test protocol devised here could serve the same purpose as the Warren Spring Boat Test, being used on a fairly regular basis to test oils and dispersants under a variety of conditions. It would be a useful "stepping stone" between the laboratory tests and the full scale tests.

Several operational recommendations are included here to improve the conduct of any future tests.

1. Communications between the vessel and aircraft, or between the vessel and shore would ensure that essential personnel arrive on site without unnecessary delay.

2. Additional lead time would enable necessary approvals and permits to be obtained in advance, without jeopardizing the field program through unpredictable changes in schedule.

3. Extra sorbent should be stockpiled on shore and brought to the site as needed. Inadequate sorbent was on hand to complete the experiment as planned.

4. Spills should take place in daylight hours to enable detailed observations and photography.

5. A minimum of six days is required to ensure successful completion of a two day arctic test (allowing for deployment, clean-up, and weather problems).

6. In situ measurements of oil concentration should be taken to ensure that meaningful samples are collected.